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Performance Analysis of Single Phase Induction Motor Coated with Al_2O_3 Nano Filler Mixed Enamel

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***Abstract*— In the last decades, it has been shown that the properties of the enamel used in the induction motor were improved by adding the nano fillers to it. The performance of the motor was also improved by using the enamel filled with the nano fillers. In this paper, the performance of the single phase induction motor coated with Al_2O_3 nano filler mixed enamel was analyzed by conducting many tests such as open circuit test, short circuit test, load test and thermal withstanding test on it and the results were compared with that of the normal single phase induction motor. The test results show that there was a tremendous improvement in the performance of the single phase induction motor coated with Al_2O_3 nano filler mixed enamel when compared to that of the normal single phase induction motor. The efficiency of the induction motor was increased to a maximum 6 % by adding nano filler of Al_2O_3 to the enamel used as the coating for the windings in the single phase induction motor. The addition of nano fillers to the enamel has increased the temperature withstanding capacity of the induction motor. Hence the life time of the motor will be increased.**

***Index Terms*— Single Phase Induction motor, Enamel, Coating, Nano Filler, Al_2O_3, Harmonics, Load test, Open circuit test, Blocked rotor test, EMI and EMC.**

I. INTRODUCTION

Single-phase induction motors were used extensively for smaller loads in industries. Although most AC motors have long been used in fixed-speed load drive service, they were increasingly being used in variable-frequency drive (VFD) service, variable-torque centrifugal fan, pump and compressor loads being by far the most important energy saving applications for VFD service. Squirrel cage induction motors are most commonly used in both fixed-speed and VFD applications. The efficiency of the induction motor depends upon the insulation used [1]. For motors, the enamel was used for three purposes: impregnation, coating and adhesion. The efficiency of the induction motor can be increased by adding the nano fillers with the enamel which was used as coating for the windings of the motor. In this paper, the performance of the normal single phase induction motor and the nano alumina filled enamel coated single phase squirrel cage induction motor was analyzed and the results were compared with each other.

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II. PROPOSED WORK

The micro particles of alumina were converted into nano particles by using ball mill method [4] [6]. The particle size was augment by SEM [7]. The enamel was mixed with the alumina nano fillers with the help of ultrasonic vibrator [8] [9]. Then this enamel filled with alumina nano filler was coated to the windings of the induction motor. Several tests were conducted to examine the efficiency, thermal withstanding capacity, harmonics and EMI of this motor [2] [3]. The several steps involved in this project were shown in the figure 1.

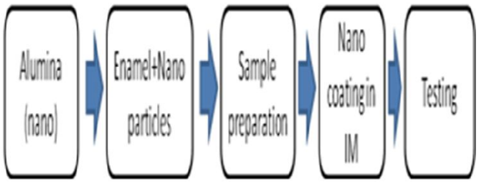

Figure 1 Block diagram of proposed work

The specifications of the single phase capacitor start capacitor run motor used for this research work were shown in the table I.

TABLE I. SPECIFICATION OF SINGLE PHASE MOTOR

Quantity	Rating
Phase	1Φ
Capacity	0.5 HP
Voltage	230V
Current	4 A
Speed	1500

III. PERFORMANCE ANALYSIS OF INDUCTION MOTOR WITHOUT AND WITH NANO COATED COPPER WINDING

The performance of induction motor was analyzed by conducting various tests such as Open circuit test, Short circuit test, Load test, Thermal withstanding test, measurement of Electro Magnetic Interference and Harmonics. Open circuit test and short circuit test were conducted to predetermine the efficiency of the motor whereas the efficiency of the induction motor was determined by load test. The thermal performance of the motor was obtained by conducting thermal withstand test. Electro Magnetic Interference was measured in the terms of Gauss and Tesla by using Gauss meter and Tesla meter. Power Quality Analyser was used to measure the harmonics in terms of voltage THD and current THD.

A. Open Circuit Test on Induction Motor without and with Nano Coated Copper Winding

Open Circuit Test was conducted on the motor under no load condition [5]. The input current, voltage and power were measured by connecting the ammeter, voltmeter and wattmeter in the circuit. The following table 2 and 3 show the No-load test readings of induction motor without and with nano coated copper winding.

TABLE II. NO-LOAD TEST READINGS OF INDUCTION MOTOR WITHOUT NANO COATED COPPER WINDING

Line Voltage (v)	Line Current (A)	Reading	Power	Speed N in rpm
220	3.7	35	140	1485

TABLE III. NO-LOAD TEST READINGS OF INDUCTION MOTOR WITH NANO COATED COPPER WINDING

Line Voltage (v)	Line Current (A)	Reading	Power	Speed N in rpm
220	3.9	40	160	1495

B. Short Circuit Test on Induction Motor without and with Nano Coated Copper Winding

In Blocked rotor test, the rotor was held fixed so that it will not rotate [10]. A reduced voltage was applied to limit the short circuit current. This voltage was adjusted with the help of autotransformer so that the rated current flows through main winding. The input voltages, current and power were measured by connecting voltmeter, ammeter and wattmeter respectively. Figure 2 shows the circuit diagram for the blocked rotor test.

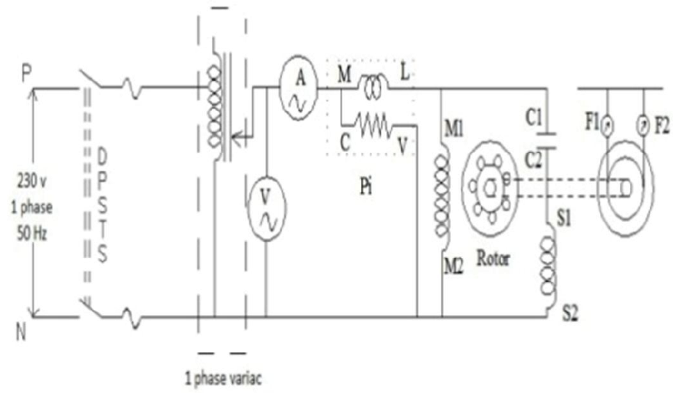

Figure 2 Circuit Diagram for Short Circuit test

The following table 4 and 5 show the Blocked rotor test readings of induction motor without and with nano coated copper winding.

TABLE IV. BLOCKED ROTOR TEST OF INDUCTION MOTOR WITHOUT NANO COATED COPPER WINDING

Line Voltage (v)	Line Current (A)	Reading	Power	Speed N in rpm
80	4	65	260	0

TABLE V. BLOCKED ROTOR TEST OF INDUCTION MOTOR WITH NANO COATED COPPER WINDING

Line Voltage (v)	Line Current (A)	Reading	Power	Speed N in rpm
41	4	35	140	0

C. Load test on Induction Motor without and with Nano Coated Copper Winding

Efficiency was determined by conducting load test on the induction motor as per the circuit diagram shown in the figure 3.

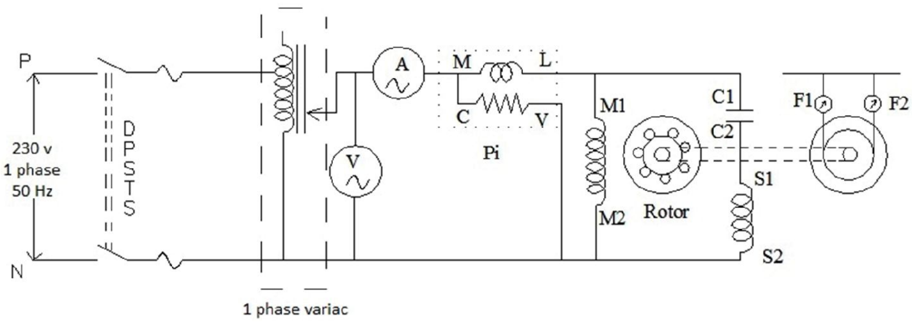

Figure 3 Circuit Diagram for Load test on Single Phase Induction Motor

The efficiency of the nano coated motor was increased to a maximum of 6 percent. This was mainly due to reduction of dielectric losses in Nano coated motor [12]. The readings were calculated for various loads and tabulated below in Table 6.

D. Thermal withstanding test on Induction Motor without and with Nano Coated Copper Winding

Temperature of dielectric material in copper winding of induction motor was highly related with its life time [10] [12] [13]. The motor was given the rated voltage of 230 volt with the help of autotransformer. The motor was loaded at different load current. The thermometer was placed on the copper winding of induction motor. The values of temperature withstanding capacity of Induction motor in both cases were tabulated below in Table 7.

TABLE VI. LOAD TEST READINGS OF INDUCTION MOTOR WITHOUT AND WITH NANO COATED COPPER WINDING

Motor Without nano coating		Motor With nano coating	
Current (A)	Efficiency (%)	Current (A)	Efficiency (%)
3.9	41.46	4	53.65
4	51.31	4.1	65.15
4.2	69.50	4.2	67.79
4.3	69.22	4.3	72.40
4.4	68.73	4.4	74.49

TABLE VII. THERMAL WITHSTANDING CAPACITY OF INDUCTION MOTOR WITHOUT AND WITH NANO COATED COPPER WINDING

Time (min)	Without Nano coating (Celsius)	With Nano coating (Celsius)
0	30	30
5	44	40
10	48	43
15	50	46
20	53	49
25	55	50
30	57	53

E. Measurement of electromagnetic interference on Induction Motor without and with Nano Coated Copper Winding

The electromagnetic interference was measured by means of Gauss meter and Tesla meter. Table 8 shows the values of electromagnetic interference produced normal induction motor and nano coated induction motor in terms of Gauss and Tesla [5] [11]. From these measurements, it was observed that there was a reduction of 5-15 % in the values of the electromagnetic interference produce by the normal induction motor when compared to that of nano composite filled enamel coated induction motor at various distances.

TABLE VIII. MEASUREMENT OF ELECTROMAGNETIC INTERFERENCE OF INDUCTION MOTOR WITHOUT AND WITH NANO COATED COPPER WINDING

Distance in cm	Without nano coating (milligauss)	With nano coating (milligauss)
7	155	130
9	104	80
10	78	65
12	47	45
14	32	30
15	26	25
20	10	5

F. Measurement of Harmonics on Induction Motor without and with Nano Coated Copper Winding

Harmonics measurement of an industrial unit was done to asset the power quality aspects in a typical factory. The harmonics of network voltage will have effect on operation of all electrical equipment like relays, measurement equipment and electric motors. Many parameters like different load cycling, switching, working in hot weather, harmonics and unbalances were the major reasons for temperature rise of the motors. The electrical losses such as iron, winding and stray load losses will depend on order and magnitude of harmonics. Hysteresis loss and eddy current loss that take place in the Iron vary with the square of the air-gap

voltage. The harmonic currents are proportional to the magnitude of voltage harmonics, i.e. the stray load loss and winding loss vary with the square of the voltage harmonic.

Voltage THD of induction motor without and with nano coated copper winding: Voltage THD was measured using Power Quality Analyser. For the rated voltage the maximum THD for induction motor without nano coated copper winding was recorded as 8.7%. The maximum THD recorded after the coating of alumina nano filler in the copper winding of single phase induction motor was 3.9%. The influence of 5th and 7th harmonics was also reduced. Figure 4 shows the voltage THD comparison.

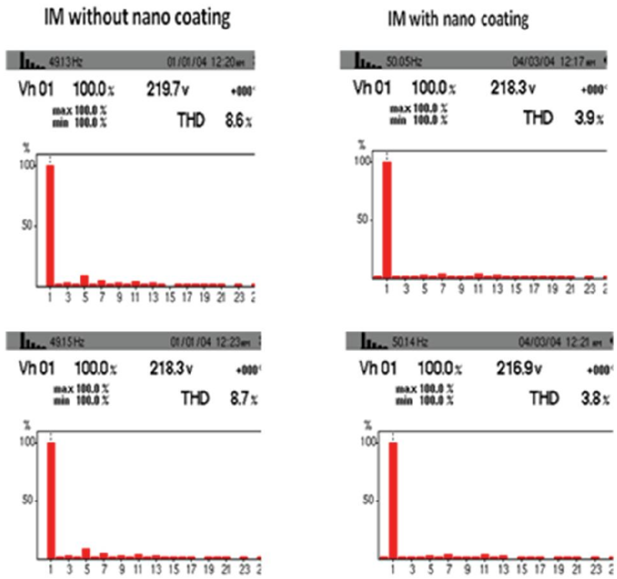

Figure 4 Voltage THD Comparisons

Current THD of induction motor without and with nano coated copper winding: Current THD was also measured using Power Quality Analyser. For the rated current of 4.0A the maximum THD for induction motor without nano coated copper winding was recorded as 7.8%. The maximum THD recorded after the coating of alumina nano filler in the copper winding of single phase induction motor was 3.6%. The influences of 5th and 7th harmonics were also reduced. Figure 5 shows the current THD comparison.

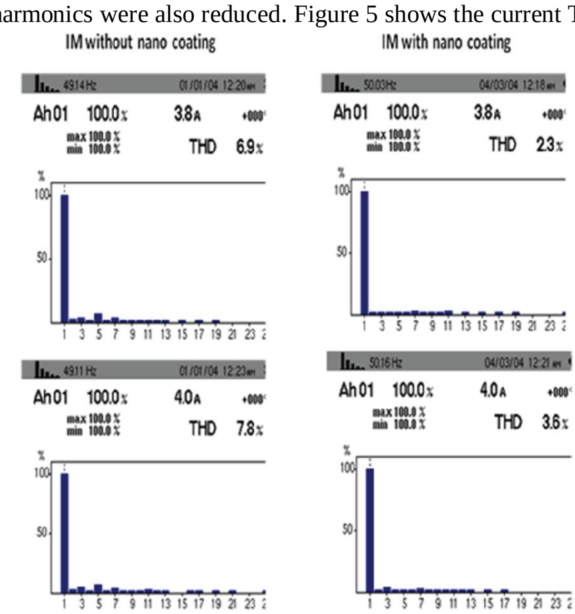

Figure 5 Current THD Comparisons

IV. CONCLUSION

The following observations were clear as per this study:

1. The efficiency of the induction motor was increased to a maximum 6 % by adding nano filler of Al_2O_3 to the enamel used as the coating for the windings in the single phase induction motor.
2. The addition of nano fillers to the enamel has increased the temperature withstanding capacity of the induction motor. Hence the life time of the motor will be increased.
3. There was a reduction of 5 to 15% in the values of the electromagnetic interference produced by the Induction motor without nano coated copper winding when compare to that of nano composite filled enamel copper winding of Induction motor
4. By the addition of alumina nano fillers in the copper winding of single phase induction motor there was reduction in the THD by 55% which in turn reduces the Iron, winding and stray load losses occur in induction motor.

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REFERENCES

[1] E.L Brancato, “Estimating the Lifetime Expectancies of Motors,”,IEEE Electrical Insulation Magazine, Vol. 8, No. 3, pp5 13, May/June 1992.

[2] H.Oraee, “A Quantitative Approach to Estimate the Life Expectancy of Electric Motors”, IEEE Transaction on Dielectrics and Electrical Insulation, Vol. 7, No. 6, Dec. 2000, pp. 790-796.

[3] K. Inuzuka, H. Inano, N. Hayakawa, T. Hirose, M. Hamaguchi, and H. Okubo, “ Partial discharge characteristics of nanocomposite enameled wire for inverter fed motor,” 2006Annu. Rep. Conf. Elect. Insul. Dielect. Phenomena, Kansas City, 2006, pp. 594-597.

[4] Pugazhendhi Sugumaran. C, Mohan. M.R and Udayakumar. K, “Investigation of Dielectric and Thermal Properties of Nano-filler (ZrO2) Mixed Enamel”, IEEE Transaction on Dielectrics and Electrical Insulation: Vol.17, No.6, 2010.

[5] Selvaraj, D. Edison, et al. "Analysis of Efficiency, Thermal Withstanding Capacity and Electromagnetic Interference of Three Phase Squirrel Cage Induction Motor Coated with SiO_2 & TiO_2 nanocomposite Filled Enamel." International Journal of Science and Engineering Applications 1.1 (2012): 17-21.

[6] Edison Selvaraj, D., C. Pugazhendhi Sugumaran, and A. Sivaprakash. "Characterization of Electrical and Thermal Properties of Enamel Filled with Carbon Nanotubes." Proceedings of the Third International Conference on Trends in Information, Telecommunication and Computing, 496 – 502, Springer New York, 2013.

[7] Selvaraj, D. Edison. "Partial discharge characteristics of enamel filled with micro and nano composite of siO_2 and TiO_2." International Journal of Science and Engineering Applications 1.2 (2012): 95-101.

[8] Selvaraj, D. Edison. "Characterization of dielectric properties of the enamel filled with carbon nanotubes for the frequency range of 50 Hz-5 MHz" International Journal of Science and Engineering Applications 1.2 (2012): 102-106.

[9] Selvaraj, D. Edison, and C. Pugazhendhi Sugumaran. "Comparative Analysis of Dielectric Properties of Enamel Filled with Various Nanofillers such as ZrO_2, Al_2O_3, CNT and ZnO." International Journal of Science and Engineering Applications 1.1 (2012): 51-55.

[10] D.Edison Selvaraj, J. Ganesan. "Experimental Analysis of Efficiency and Thermal Withstanding Capacity of Three Phase Squirrel Cage Induction Motor Coated with SiO_2 & TiO_2 Nano Composite Filled Enamel", International Journal of Engineering Sciences, Vol (2), No (4), 2013. Pp. 115-118.

[11] Lieutenant Ganesan. J, Selva Kumar. B, P. Agnel Rozario & O.R. Srinivas Krishna, Edison Selvaraj. D, “Reduction of electromagnetic Interference in three phase squirrel cage Induction Motor by coating of nano composite filled enamel to the winding of the Motor” pp 61-65, Seek Digital Library, Singapore, 2013.

[12] Lieutenant Ganesan. J, Edison Selvaraj. D, Gurprakash. B, Vishnu Prakash. R, Muthupandi. E and Balakumar. R, “Analysis of Efficiency and Thermal Withstanding Capacity of Single Phase Induction Motor Coated with Al_2O_3 Nano Filler Mixed Enamel”, International journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol.2,Issue 3,pp. 960-963, 2013.

[13] Edison Selvaraj. D, Lieutenant Ganesan. J, and Selva Kumar. B, “Analysis of Thermal withstanding capacity of three phase Squirrel Cage Induction Motor coated with SiO_2 and TiO_2 nano composite filled enamel” Proceeding of CEEE 2013, pp 31-34, Seek Digital Library, Singapore, 2013.